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CLAIMS

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-- 47. A vapor phase growth method of a metal oxide dielectric film on a substrate using organometal gases, comprising: a step of carrying out film formation by introducing the organometal gases and an oxidizing gas into a vacuum chamber through separate introduction inlets while heating the substrate set in the vacuum chamber and keeping the total pressure of the vacuum chamber at 1×10^{-2} Torr or lower.

48. A vapor phase growth method of a metal oxide dielectric film according to claim 47, wherein the substrate temperature is at 450°C or lower during the film formation.

49. A vapor phase growth method of a metal oxide dielectric film according to claim 47, wherein the total pressure of the vacuum chamber is at 1×10^{-4} Torr or higher and 1×10^{-2} Torr or lower.

50. A vapor phase growth method of a metal oxide dielectric film according to claim 47, wherein the oxidizing gas comprises nitrogen dioxide gas.

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51. A vapor phase growth method of a metal oxide dielectric film according to claim 47, wherein the film formation is carried out by controlling the gas supply conditions for the organometal gases and/or the oxidizing gas to be self-controlling gas supply conditions as to obtain the metal oxide dielectric film having a prescribed composition and crystal structure.

52. A vapor phase growth method of a metal oxide dielectric film according to the claim51, wherein the flow rates of organometal gases and the oxidizing gas are directly controlled without using a carrier gas to introduce the organometal gases and the oxidizing gas into the vacuum chamber.

53. A vapor phase growth method of a metal oxide dielectric film according to claim 47, wherein the metal oxide dielectric film is a PZT film or a BST film.

54. A vapor phase growth method of a metal oxide dielectric film according to claim47, wherein the substrate has capacitor electrodes formed thereon which comprises at least any one of metals or metal oxides of Pt, Ir, Ru, IrO_2, RuO_2, TiN, or WN and the metal oxide dielectric film is formed on the substrate in vapor phase.

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55. A vapor phase growth method of a metal oxide dielectric film according to claim 47, wherein the substrate has an Al wiring formed thereon and the metal oxide dielectric film is formed on the substrate in vapor phase.

56. A vapor phase growth method of a metal oxide dielectric film according to claim 47, wherein the temperature of the inner walls of the vacuum chamber is equal to or higher than a temperature to allow the organometal gases to have a sufficiently high vapor pressure and equal to or lower than an organometal gas decomposition temperature.

57. A method for fabricating a semiconductor device, comprising: a step of forming a MOS-type transistor on a semiconductor substrate, a step of forming a first interlayer insulation film on the transistor, a step of forming electric conduction by opening a contact reaching the diffusion layer of the MOS-type transistor in the first interlayer insulation film and burying a metal plug in the contact, a step of forming a capacitor lower part electrode layer on the whole surface of the first interlayer insulation film having the metal plug, a step of forming a metal oxide dielectric film on the whole surface of the capacitor

lower part electrode layer using organometal gases and an oxidizing gas at 1×10^{-4} Torr or higher to 1×10^{-2} Torr or lower of the total pressure while keeping the temperature of the semiconductor substrate at 450°C or lower, a step of forming a capacitor upper part electrode layer on the whole surface of the metal oxide dielectric film, and a step of patterning the lower part electrode layer, the metal oxide dielectric film, and the capacitor upper part electrode layer to obtain a capacitor with a three-layered laminated structure.

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58. A method for fabricating a semiconductor device, comprising: a step of forming a MOS-type transistor on a semiconductor substrate, a step of forming a first interlayer insulation film on the transistor, a step of forming electric conduction by opening a contact reaching the diffusion layer of the MOS-type transistor in the first interlayer insulation film and burying a metal plug in the contact, a step of forming a capacitor lower part electrode layer on the whole surface of the first interlayer insulation film having the metal plug, a step of forming a capacitor lower part electrode on the metal plug by patterning the capacitor lower part electrode, a step of forming a metal oxide dielectric film on the patterned capacitor lower part electrode and on the whole surface of the first

interlayer insulation film using organometal gases and an oxidizing gas at 1×10^{-4} Torr or higher to 1×10^{-2} Torr or lower of the total pressure while keeping the temperature of the semiconductor substrate at 450°C or lower, a step of forming a capacitor upper part electrode layer on the whole surface of the metal oxide dielectric film, and a step of patterning the capacitor upper part electrode layer to obtain a capacitor with a three-layered laminated structure of the capacitor lower part electrode, the metal oxide dielectric film, and the capacitor upper part electrode.

59. A method for fabricating a semiconductor device, comprising: a step of forming a MOS-type transistor on a semiconductor substrate, a step of forming a first interlayer insulation film on the transistor, a step of forming electric conduction by opening a contact reaching the diffusion layer of the MOS-type transistor in the first interlayer insulation film and burying a metal plug in the contact, a step of forming an aluminum wiring electrically connected to the metal plug on the first interlayer insulation film, a step of forming a second interlayer insulation film on the aluminum wiring, a step of forming electric conduction by opening a contact reaching the aluminum wiring in the second interlayer insulation film and

burying a metal plug, a step of forming a capacitor lower part electrode layer on the whole surface of the second interlayer insulation film including the metal plug, a step of forming a metal oxide dielectric film on the whole surface of the capacitor lower part electrode layer using organometal gases and an oxidizing gas at 1×10^{-4} Torr or higher to 1×10^{-2} Torr or lower of the total pressure while keeping the temperature of the semiconductor substrate at 450°C or lower, a step of forming a capacitor upper part electrode layer on the whole surface of the metal oxide dielectric film, and a step of patterning the capacitor lower part electrode layer, the metal oxide dielectric film, and the capacitor upper part electrode layer to obtain a capacitor with a three-layered laminated structure.

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60. A method for fabricating a semiconductor device according to claim 59, wherein aluminum wiring to be formed in the lower layer of the capacitor is made multilayered by repeating, at least one time before the capacitor lower part electrode layer is formed, a step of forming an aluminum wiring electrically conducting to the finally formed metal plug, a step of forming an interlayer insulation film on the aluminum wiring, and a step of forming electric conduction by opening a contact reaching the aluminum wiring in the interlayer insulation

film and burying a metal plug in the contact.

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61. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film with a perovskite type crystal structure represented by ABO_3 on a conductive material using organometal gases, comprising steps of: carrying out initial nuclei formation of the perovskite type crystal structure on the conductive material using all of the organometal gases to be the raw materials of the metal oxide dielectric film under first film formation conditions, and carrying out film formation of the perovskite type crystal structure further on the initial nuclei under second film formation conditions.

62. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film with a perovskite type crystal structure represented by ABO_3 on a conductive material using organometal gases, comprising steps of: carrying out initial layer formation of the perovskite type crystal structure on the conductive material using all of the organometal gases to be the raw materials of the metal oxide dielectric film under first film formation conditions and carrying out film formation of the perovskite type crystal structure further on the initial layer under second film formation conditions.

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63. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film with a perovskite type crystal structure represented by ABO_3 on a conductive material using organometal gases, comprising steps of: carrying out initial nuclei formation of the perovskite type crystal structure on the conductive material using only a part of the organometal gases to be the raw materials of the metal oxide dielectric film under first film formation conditions and carrying out film formation of the perovskite type crystal structure further on the initial nuclei under second film formation conditions.

64. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 61 , wherein the second film formation conditions are so set as to carry out film formation using raw material gas supply in good self-controlling conditions, and the raw material of the A element is supplied in a higher quantity in the first film formation conditions than that in the second film formation conditions.

65. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 62 , wherein the second film formation conditions

are so set as to carry out film formation using raw material gas supply in good self-controlling conditions, and the raw material of the A element is supplied in a higher quantity in the first film formation conditions than that in the second film formation conditions.

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66. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 63, wherein the second film formation conditions are so set as to carry out film formation using raw material gas supply in good self-controlling conditions, and the raw material of the A element is supplied in a higher quantity in the first film formation conditions than that in the second film formation conditions.

67. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 61 , wherein the supply amount of Zr in the B element, in the case where the B element includes both Zr and Ti, is decreased relatively to that of Ti in the first film formation conditions as compared with in the second film formation conditions.

68. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 62 , wherein the supply amount of Zr in the B

element, in the case where the B element includes both Zr and Ti, is decreased relatively to that of Ti in the first film formation conditions as compared with in the second film formation conditions.

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69. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 63 , wherein the supply amount of Zr in the B element, in the case where the B element includes both Zr and Ti, is decreased relatively to that of Ti in the first film formation conditions as compared with in the second film formation conditions.

70. A vapor phase growth method according to claim 63, wherein the first film formation conditions are so controlled as to supply no Zr raw material gas in film formation in the case Zr and other elements are contained as the B element.

71. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 61, wherein the film formation is carried out while controlling the crystal grain size by controlling the duration time of the initial nuclei formation in the first film formation conditions.

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72. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 63 , wherein the film formation is carried out while controlling the crystal grain size by controlling the duration time of the initial nuclei formation in the first film formation conditions.

73. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 61 , wherein the total pressure of the raw material gases including the organometal gases at the time of film formation is kept at 1×10^{-2} Torr or lower.

74. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 62 , wherein the total pressure of the raw material gases including the organometal gases at the time of film formation is kept at 1×10^{-2} Torr or lower.

75. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 63 , wherein the total pressure of the raw material gases including the organometal gases at the time of film formation is kept at 1×10^{-2} Torr or lower.

76. A vapor phase growth method for carrying out

film formation of a metal oxide dielectric film according to claim 73 , wherein the film formation temperature is kept at 450°C or lower.

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77. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 74 , wherein the film formation temperature is kept at 450°C or lower.

78. A vapor phase growth method for carrying out film formation of a metal oxide dielectric film according to claim 75 , wherein the film formation temperature is kept at 450°C or lower.

79. A vapor phase growth method of a metal oxide dielectric film according to claim 61 , wherein the metal oxide dielectric film is a PZT film or a BST film.

80. A vapor phase growth method of a metal oxide dielectric film according to claim 63 , wherein the metal oxide dielectric film is a PZT film or a BST film.

81. A vapor phase growth method of a metal oxide dielectric film according to claim 63 , wherein the metal oxide dielectric film is a PZT film or a BST film.

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82. A vapor phase growth method of a metal oxide dielectric film according to claim 61, wherein the conductive material is a capacitor electrode comprising at least any one of metals and metal oxides of Pt, Ir, Ru, IrO_2, RuO_2, TiN, and WN.

83. A vapor phase growth method of a metal oxide dielectric film according to claim 62, wherein the conductive material is a capacitor electrode comprising at least any one of metals and metal oxides of Pt, Ir, Ru, IrO_2, RuO_2, TiN, and WN.

84. A vapor phase growth method of a metal oxide dielectric film according to claim 63, wherein the conductive material is a capacitor electrode comprising at least any one of metals and metal oxides of Pt, Ir, Ru, IrO_2, RuO_2, TiN, and WN.

85. A vapor phase growth method of a metal oxide dielectric film according to claim 61, wherein the conductive material has a three-layered structure of Pt/TiN/Ti.

86. A vapor phase growth method of a metal oxide dielectric film according to claim 62, wherein the conductive material has a three-layered structure of

Pt/TiN/Ti.

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87. A vapor phase growth method of a metal oxide dielectric film according to claim 63 , wherein the conductive material has a three-layered structure of Pt/TiN/Ti.

88. A vapor phase growth method of a metal oxide dielectric film according to claim 61 , wherein the conductive material has a four-layered structure of Pt/TiN/Ti/W.

89. A vapor phase growth method of a metal oxide dielectric film according to claim 62, wherein the conductive material has a four-layered structure of Pt/TiN/Ti/W.

90. A vapor phase growth method of a metal oxide dielectric film according to claim 63 , wherein the conductive material has a four-layered structure of Pt/TiN/Ti/W.

91. A method for fabricating a semiconductor device, comprising: a step of forming a MOS-type transistor on a semiconductor substrate, a step of forming a first interlayer insulation film on the transistor, a step of forming electric conduction by

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opening a contact reaching the diffusion layer of the MOS-type transistor in the first interlayer insulation film and burying a metal plug in the contact, a step of forming a capacitor lower part electrode layer on the whole surface of the first interlayer insulation film having the metal plug, a step of forming initial nuclei or an initial layer of a metal oxide dielectric film having the perovskite type crystal structure on the whole surface of the capacitor lower part electrode layer using organometal gases under the first film formation conditions and further forming the metal oxide dielectric film having the perovskite type crystal structure on the initial nuclei or the initial layer under the second film formation conditions, a step of forming a capacitor upper part electrode layer on the whole surface of the metal oxide dielectric film, and a step of patterning the capacitor lower part electrode layer, the metal oxide dielectric film, and the capacitor upper part electrode layer to obtain a capacitor with a three-layered laminated structure.

92. A method for fabricating a semiconductor device comprising: a step of forming a MOS-type transistor on a semiconductor substrate, a step of forming a first interlayer insulation film on the transistor, a step of forming electric conduction by

opening a contact reaching the diffusion layer of the MOS-type transistor in the first interlayer insulation film and burying a metal plug in the contact, a step of forming a capacitor lower part electrode layer on the whole surface of the first interlayer insulation film having the metal plug, a step of forming a capacitor lower part electrode on the metal plug by patterning the capacitor lower part electrode layer, a step of forming initial nuclei or an initial layer of a metal oxide dielectric film having the perovskite type crystal structure on the whole surface of the patterned capacitor lower part electrode and the first interlayer insulation film layer using organometal gases under the first film formation conditions and further forming the metal oxide dielectric film having the perovskite type crystal structure on the initial nuclei or the initial layer under the second film formation conditions, a step of forming a capacitor upper part electrode layer on the whole surface of the metal oxide dielectric film, and a step of patterning the capacitor upper part electrode layer to obtain a capacitor with a three-layered laminated structure of the capacitor lower part electrode, the metal oxide dielectric film, and the capacitor upper part electrode.

93. A method for fabricating a semiconductor

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device, comprising a step of forming a MOS-type transistor on a semiconductor substrate, a step of forming a first interlayer insulation film on the transistor, a step of forming electric conduction by opening a contact reaching the diffusion layer of the MOS-type transistor in the first interlayer insulation film and burying a metal plug in the contact, a step of forming an aluminum wiring on the first interlayer insulation film to electrically connecting the aluminum wire with the metal plug, a step of forming a second interlayer insulation film on the aluminum wiring, a step of forming electric conduction by opening a contact reaching the aluminum wiring in the second interlayer insulation film and burying a metal plug in the contact, a step of forming a capacitor lower part electrode layer on the whole surface of the second interlayer insulation film having the metal plug, a step of forming initial nuclei or an initial layer of a metal oxide dielectric film having the perovskite type crystal structure on the whole surface of the whole surface of the capacitor lower part electrode layer using organometal gases under the first film formation conditions and further forming the metal oxide dielectric film having the perovskite type crystal structure on the initial nuclei or the initial layer under the second film formation conditions, a step of forming a capacitor upper part electrode layer on the

whole surface of the metal oxide dielectric film, and a step of patterning the capacitor lower part electrode layer, the metal oxide dielectric film, and the capacitor upper part electrode layer to obtain a capacitor with a three-layered laminated structure.

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94. A method for fabricating a semiconductor device according to claim 93, wherein aluminum wiring to be formed in the lower layer of the capacitor is made multilayered by repeating, at least one time before the capacitor lower part electrode layer is formed, a step of forming an aluminum wiring electrically conducting to the finally formed metal plug, a step of forming an interlayer insulation film on the aluminum wiring, and a step of forming electric conduction by opening a contact reaching the aluminum wiring in the interlayer insulation film and burying a metal plug in the contact.

95. An apparatus to be employed for vapor phase growth of a metal oxide dielectric material on a substrate in a vacuum chamber using organometal gases and an oxidizing gas as raw material gases by brining these gases into contact with one another, comprising: an apparatus part to be brought into contact with raw material gases and to be heated to the temperature equal to or higher than the decomposition temperature of the

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raw material gases; at least the surface of the apparatus part to which the raw material gases contact being made of a metal oxide dielectric material (hereafter referred to as a high temperature part-coating dielectric material) same or not same as the metal oxide dielectric material to be grown.

96. An apparatus for vapor phase growth according to claim 95, wherein the high temperature part-coating dielectric material is a material selected from the group consisting of $SrTiO_3$, $BaTiO_3$, $PbTiO_3$, $Pb(Zr, Ti)O_3$, $(Ba, Sr)TiO_3$, $(Pb, La)(Zr, Ti)O_3$, $(Pb, Nb)(Zr, Ti)O_3$, and $SrBi_2Ta_2O_9$.

97. An apparatus for vapor phase growth according to claim 95, wherein the apparatus part to be brought into contact with raw material gases and heated to the temperature equal to or higher than the decomposition temperature of the raw material gases comprises a susceptor for supporting a substrate.

98. A vapor phase growth apparatus to be employed for vapor phase growth of a metal oxide dielectric material on a substrate in a vacuum chamber using organometal gases and an oxidizing gas as raw material gases by bringing the gases into contact with one another

on the substrate, comprising: an apparatus part to be brought into contact with the raw material gases and to be heated to the temperature equal to or lower than the decomposition temperature of the raw material gases; at least the surface of the apparatus part to which the raw material gases contact being made of aluminum oxide.

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99. A vapor phase growth apparatus according to claim 98, wherein the apparatus part to be to be brought into contact with the raw material gases and heated to the temperature equal to or lower than the decomposition temperature of the raw material gases is the inner wall of a vacuum chamber to carry out vapor phase growth of a metal oxide dielectric material therein.

100. A vapor phase growth apparatus according to claim 98, wherein the apparatus part to be to be brought into contact with the raw material gases and heated to the temperature equal to or lower than the decomposition temperature of the raw material gases comprises a liner installed in the inner wall of a vacuum chamber to carry out vapor phase growth of a metal oxide dielectric material therein.

101. A vapor phase growth apparatus according to claim 95, wherein the vapor phase growth apparatus

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comprises wall heating means to heat the walls of the vacuum chamber and is to set at a temperature equal to or higher than that allowing the organometal gases to have sufficiently high vapor pressure and at a temperature equal to or lower than the decomposition temperature of each organometal gas.

102. A vapor phase growth apparatus according to claim 98, wherein the vapor phase growth apparatus comprises wall heating means to heat the walls of the vacuum chamber and is to set at a temperature equal to or higher than that allowing the organometal gases to have sufficiently high vapor pressure and at a temperature equal to or lower than the decomposition temperature of each organometal gas.

103. A vapor phase growth apparatus according to claim 95, wherein the vapor phase growth apparatus comprises respectively independent pipes as pipes for introducing respective raw material gases into the vacuum chamber.

104. A vapor phase growth apparatus according to claim 98, wherein the vapor phase growth apparatus comprises respectively independent pipes as pipes for introducing respective raw material gases into the vacuum

chamber.

105. A vapor phase growth apparatus according to claim 95, wherein the vapor phase growth apparatus comprises separately the vacuum chamber and a heater chamber equipped with a heater for heating a substrate, and the vacuum chamber and the heater chamber are independently provided with pumps for exhaust gases.

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106. A vapor phase growth apparatus according to claim 98, wherein the vapor phase growth apparatus comprises separately the vacuum chamber and a heater chamber equipped with a heater for heating a substrate, and the vacuum chamber and the heater chamber are independently provided with pumps for exhaust gases.

107. A vapor phase growth apparatus according to claim 105, wherein the vacuum chamber and the heater chamber are communicated with each other through holes for pins to exchange substrates mounted on a susceptor and in the state the substrates are mounted on the susceptor, the holes are closed by the substrates to separate the vacuum chamber and the heater chamber.

108. A vapor phase growth apparatus according to claim 106, wherein the vacuum chamber and the heater

chamber are communicated with each other through holes for pins to exchange substrates mounted on a susceptor and in the state the substrates are mounted on the susceptor, the holes are closed by the substrates to separate the vacuum chamber and the heater chamber.

109. A vapor phase growth apparatus according to claim 95, further comprising: a main exhaust line connected to a pump and a sub exhaust line equipped with a water cooling trap between the vacuum chamber and a pump as exhaust lines for evacuate the vacuum chamber.

110. A vapor phase growth apparatus according to claim 98, further comprising: a main exhaust line connected to a pump and a sub exhaust line equipped with a water cooling trap between the vacuum chamber and a pump as exhaust lines for evacuate the vacuum chamber.

111. A vapor phase growth apparatus according to claim 95, wherein the vacuum chamber is made of aluminum.

112. A vapor phase growth apparatus according to claim 97, wherein the vacuum chamber is made of aluminum.

113. A vapor phase growth apparatus to be employed for vapor phase growth of a metal oxide dielectric

material on a substrate in a vacuum chamber using organometal gases and an oxidizing gas as raw material gases by bringing these gases into contact with one another on the substrate, comprising: a valve capable of opening at the time when a substrate is put in and taken out between the forgoing vacuum chamber and an exchange chamber and with a movable shielding plate in the vacuum chamber side of the valve for preventing adhesion of raw material gases to the valve.

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114. A vapor phase growth apparatus according to claim 113, wherein the movable shielding plate is set at a temperature equal to or higher than that allowing the organometal gases to have sufficiently high vapor pressure and at a temperature equal to or lower than the decomposition temperature of each organometal gas.

115. A vapor phase growth apparatus according to claim 95 , wherein the vapor phase growth apparatus is used for formation of a capacitor film of a semiconductor device.

116. A vapor phase growth apparatus according to claim 97 , wherein the vapor phase growth apparatus is used for formation of a capacitor film of a semiconductor device.

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117. A vapor phase growth apparatus according to claim 112, wherein the vapor phase growth apparatus is used for formation of a capacitor film of a semiconductor device.--